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STRUCTURAL FLAKEBOARDS USING RING FLAKES FROM FINGERLING CHIPS.(U)
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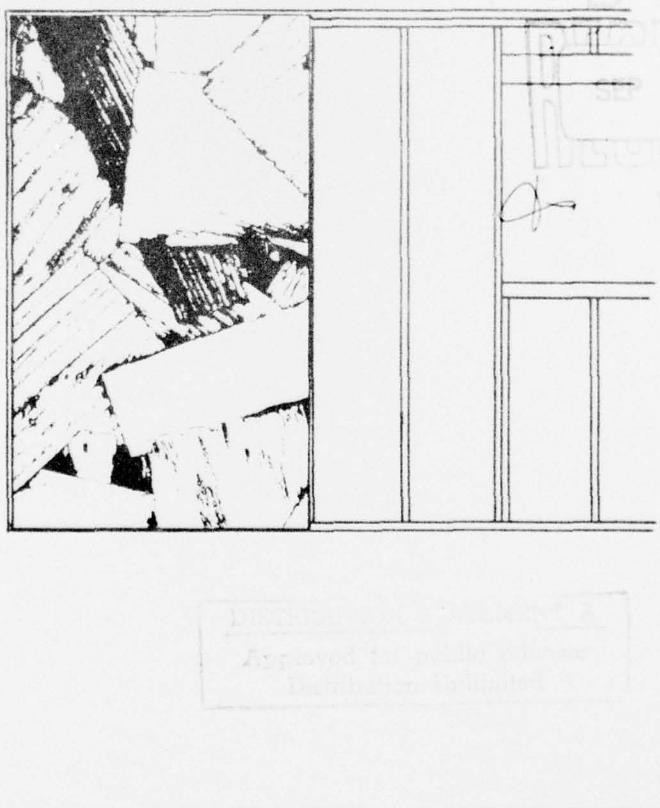

ABSTRACT

Forest residues consist of wood sections which vary in size and shape. A convenience when processing forest residues as raw material for flakeboards is to reduce the material to "fingerlings"--wood pieces 2 to 3 inches in length and 3/4 to 1 inch in cross-sectional area. In this study, West Coast forest residues of Douglas-fir and western hemlock were made first into fingerlings and then into flakes. Homogeneous flakeboards using ring flakes made from the fingerlings were evaluated for bending strength (MOR) and stiffness (MOE) both before and after accelerated aging. Strength values of fingerling-ring-flake panels were compared to the values for disk-flake panels, because disk flakes are more commonly used for structural flakeboards. The fingerling-ring-flake panels were 14 percent lower in initial MOR than disk flake panels, and 15.5 percent lower in MOE. Thus it appears difficult to produce a random three-layer panel from fingerling ring flakes that is as strong as one from conventional disk flakes.

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STRUCTURAL FLAKEBOARDS USING RING FLAKES FROM FINGERLING CHIPS

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INTRODUCTION

The wood which comprises forest residue varies widely in shape, size, and amount of contaminants such as grit and stones. To use forest residue as a raw material in manufacture, some method is needed of reducing the residue to wood pieces of a homogeneous size and shape. One such method is conversion of the residue into "fingerlings"--wood pieces approximately 2 to 3 inches in length and 3/4 to 1 inch in cross-sectional area. Fingerlings can be more easily handled, transported, and cleaned than forest residue itself. This paper discusses aspects of processing forest residue into fingerlings and the subsequent processing of fingerlings into flakeboards. Flakeboards are then evaluated for strength properties both before and after accelerated aging.

Fingerlings must be at least 2 to 3 inches in length parallel to the grain so that further reduction at the particleboard plant can produce flakes having the nominal 2-inch length recommended for structural particleboard production (4,6)[2]. Only a ring flaker presently converts chips to flakes adequately. To prepare the flakes in a ring flaker, the fingerling should be at least 3/4 to 1 square inch in cross section. In early work, fingerlings were produced by hand splitting, but a modified drum chipper is now available for evaluation of "closer to industrial" high volume production of such intermediate material (fig. 1).

The two types of machine commercially used for producing quality flakeboard furnish are disk-flakers and ring-flakers. Recent estimates (4) are available of the properties of homogeneous flakeboards using flakes from disk- and ring-flakers. In comparing the ring-flake to the disk-flake panels, the ring-flake panels were: (1) about 12 percent lower in bending stiffness (MOE); (2) equivalent in bending strength (MOR) before aging tests, but 25 percent lower after aging tests; (3) consistently lower in internal bond strength before and after aging tests; (4) equivalent in linear expansion and thickness swell.

It is known that a three-layer phenolic flakeboard employing disk flakes on the surface and ring particles in the core should perform well as a structural sheathing for housing (9). Can a board with similar properties be fabricated using ring flakes from fingerlings throughout?

[1] The Forest Products Laboratory is maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Underlined numbers in parentheses refer to literature cited at end of this report.

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To answer this question, the quality of flakeboards made from disk flakes is compared to those made from ring flakes. In addition, properties are compared for boards using ring flakes derived from two different fingerlings--those handmade and those produced on a modified drum chipper.

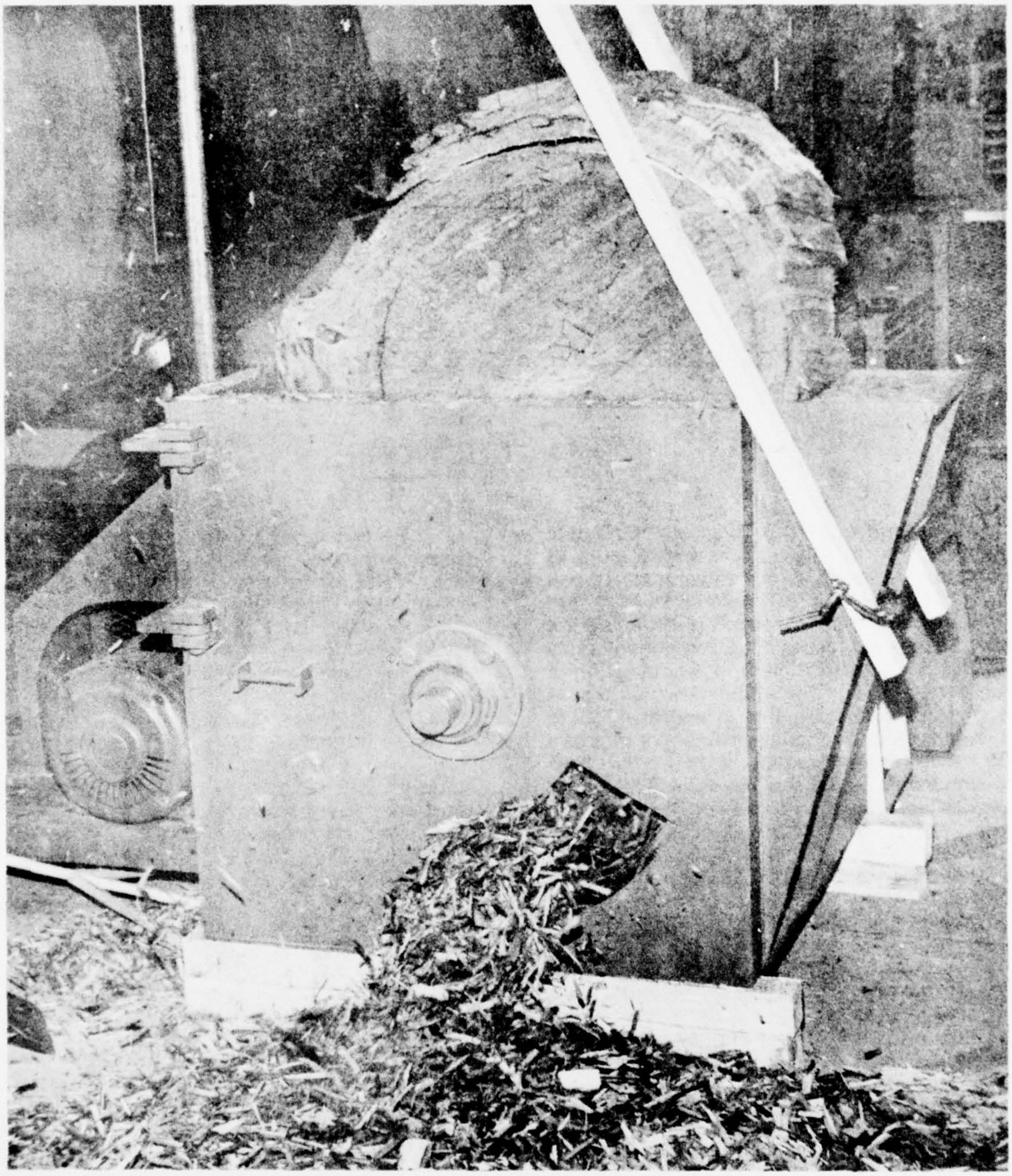

Figure 1.--Preparing fingerlings with a drum chipper.
(M 143 359-5)

FABRICATION OF TEST BOARDS

Raw Material

West Coast forest residues, consisting of Douglas-fir and western hemlock, were made first into fingerlings and then into flakeboard furnish. The residues were divided into two groups according to species and log size (fig. 2): Larger logs (30-in. diameter) were Douglas-fir; smaller logs (6- to 10-in. diameter) were 58 percent Douglas-fir and 42 percent western hemlock by weight. The larger logs were debarked; the smaller retained their bark. These groups of material were separately processed.

Sampling Analysis

The number of independent specimens required to detect differences between given properties can be calculated if variability in the property is known. The coefficients of variation of physical properties for the board to be produced can be estimated at 10 percent for MOR, 8 percent for MOE, and 10 percent for internal bond.

With this information, 18 independent specimens are required per treatment to detect a significant difference in treatment of 10 percent (±5 pct) with 90 percent confidence

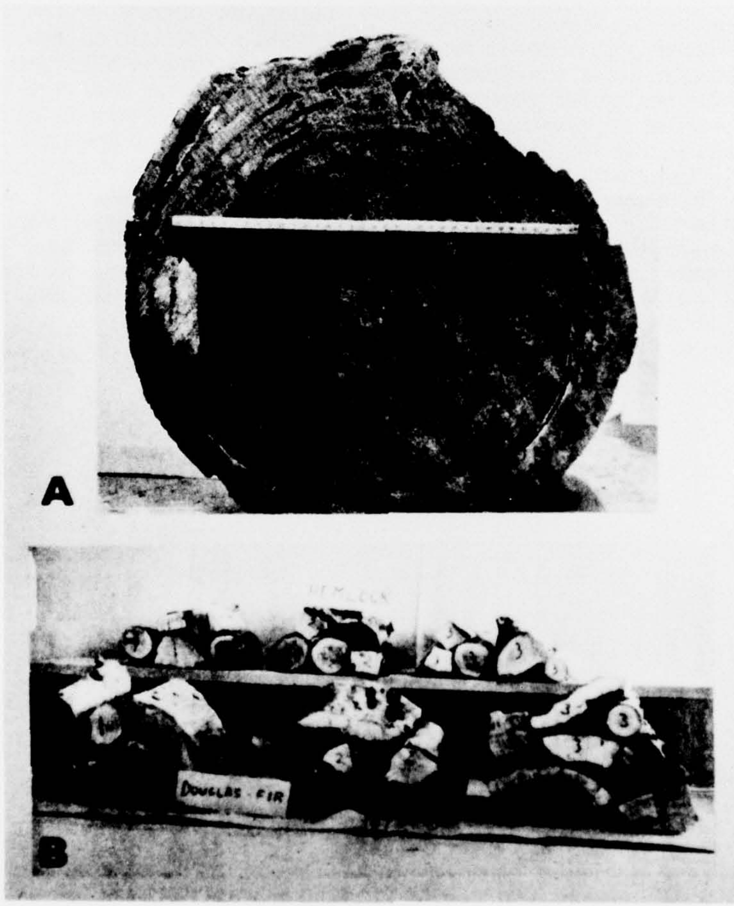

Figure 2.--Forest residues for test panels: (A) large debarked logs (30-in. diameter) of Douglas-fir, (B) small barky logs (6- to 10-in. diameter) of Douglas-fir and western hemlock.
(M 144 373)

(4). Enough panels were prepared (table 1) to obtain at least 18 specimens per panel type so as to detect this difference. All panels were 1/2 inch thick by 24 inches wide by 28 inches long, with a nominal 40-pound-per-cubic-foot density.

Furnish Preparation

Fingerlings were reduced in a ring flaker to 0.02-inch-thick by 2-inch-long flakes and were dried to 5 percent moisture content. Disk flakes were prepared with 2-1/2-inch-wide by 2-1/2-inch-thick slabs to form 0.02-inch-thick flakes. Disk flake width was reduced in a hammermill having no screen to approximate the flake width produced in the ring flaker.

After drying, all flakes were screened over a 1/32-inch mesh screen. Both the fine and coarse fractions were weighed. Only the coarse fraction was used to fabricate panels. The percentage of fines after screening is presented in table 1. The amount of fines for the residue material is very high in comparison to flaked, sound, Douglas-fir residue reported previously (7). Disk-flaked fines passing a 1/16-inch mesh comprise approximately 2.0 percent of such material, and ring-flaked fines approximately 12 to 14 percent. The residue reduced here was, therefore, clearly high in decayed wood and bark.

A mixture of 3 percent phenol formaldehyde resin[3] and 1 percent wax emulsion[3] was uniformly sprayed on the flakes as they tumbled in a drum blender. After spraying, the furnish was at 10 percent moisture content.

Panel Fabrication

The hand-felted boards were pressed in a hydraulic hot press for 10 minutes. Press closure time was 1 minute, and the press temperature was 400° F. On removal from the press, the panels were allowed to cool at room temperature with both faces exposed.

Six panels were prepared with ring flakes from hand-split fingerlings. Of these, three were prepared from the large logs with no bark and three from the small logs having bark.

Seven panels were prepared with ring flakes from drum chipper fingerlings. The fingerlings for four panels were made from the large debarked logs, and for three panels from the small logs with bark. Due to the construction of the drum chipper, some fingerlings were ejected beneath the chipper. The fingerlings ejected were longer than those which emerged from the front chute (fig. 3). Two of the seven chipper-fingerling panels were prepared of ejected fingerlings to explore the effect of this size difference on panel properties--one panel was from large logs and a second panel from small logs. The remaining five panels were prepared with fingerlings which emerged normally from the front chute of the drum chipper.

Five panels were prepared with flakes produced on the disk flaker. Of these panels, three were prepared from the large debarked logs and two from the small barky logs.

[3]Based on ovendry weight of wood.

Table 1.--Flake materials for specimen panels: Origin, reduction, and screen analysis

Form of material	Processing method	Source of material	Number of panel replicates	Percent of flaked material passed through 1/32-inch screen
Hand-split fingerlings	Ring flaker	Large logs[1] Small logs[2]	3 3	32 32
Chipper fingerlings (front chute)	Ring flaker	Large logs[1] Small logs[2]	3 2	39 30
Chipper fingerlings (ejected)[3]	Ring flaker	Large logs[1] Small logs[2]	1 1	45 34
Log sections	Disk flaker	Large logs[1] Small logs[2]	3 2	21 21
Total			18	

[1]Douglas-fir only, 30-in. diameter, bark removed.
[2]Douglas-fir (58 pct) and western hemlock (42 pct), 6-10 in. diameter, bark not removed.
[3]Fingerlings generally longer than those removed from front chute.

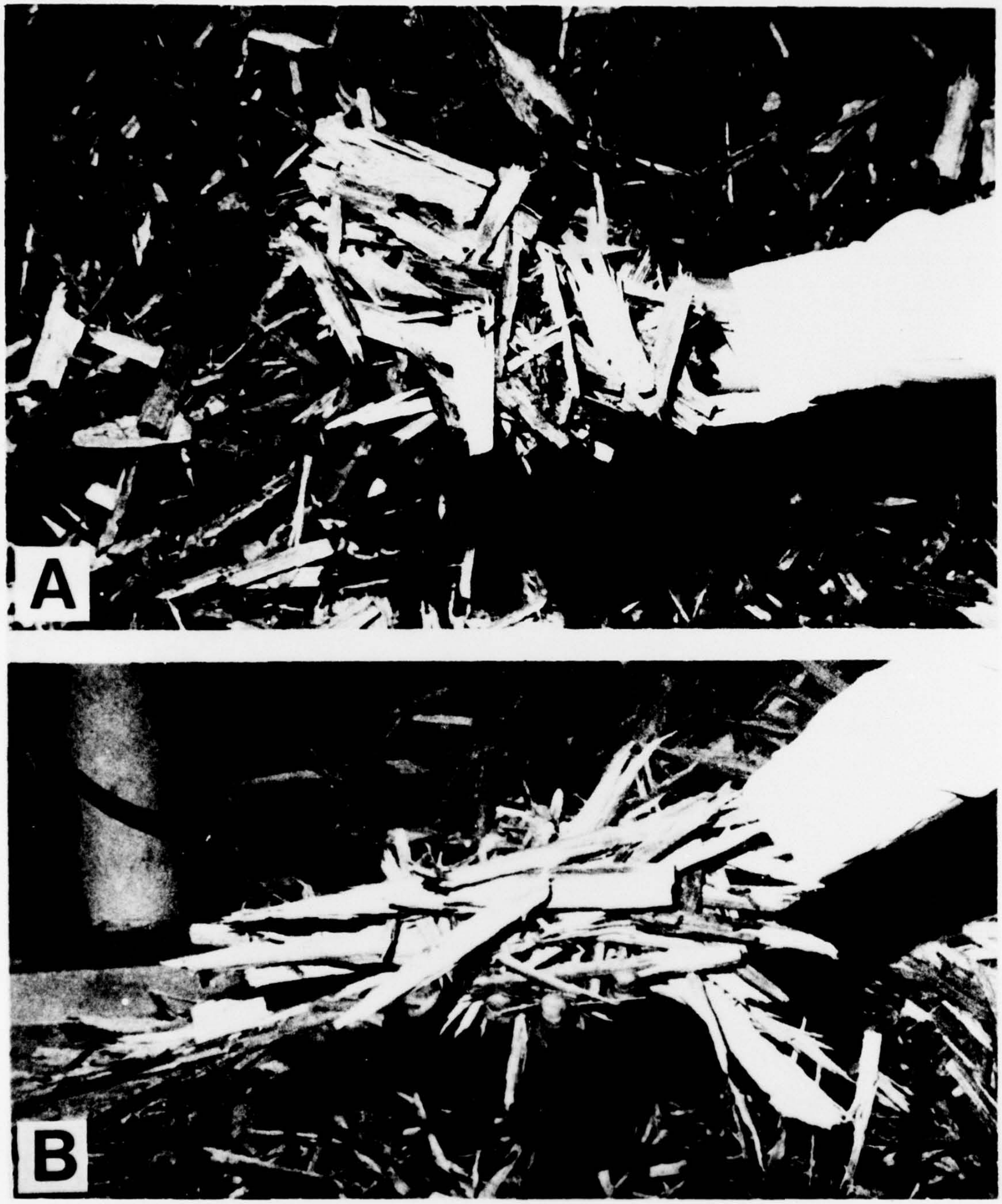

Figure 3.--Drum chipper fingerlings which have emerged from front chute (A) are smaller than fingerlings ejected beneath drum (B).
(M 143 359-11, M 143 359-12)

PANEL EVALUATION

Panels were evaluated for static bending and internal bond both before and after exposure to accelerated aging according to ASTM standard (1). The dimensional stability of specimens from ovendry to vacuum-pressure-soak (5) condition was determined also.

After the static bending tests, internal bond specimens were taken from each end of each broken bending specimen half.

Average properties of the three flakeboard types, tested under standard conditions and subjected to accelerated aging, are presented in tables A1 and A2 in the appendix.

The statistical significance of differences between flake-type processing and raw material used was determined by using a multivariate analysis of covariance technique (8). A multivariate analysis was used because more than one variable was being measured for each specimen. Analysis of these variables jointly provided more information about the processing effects than if variables were analyzed singly (univariate analysis). In the static bending tests, these variables were MOR, MOE, and internal bond (two internal bond measurements being averaged). In the dimensional stability tests, the variables were linear expansion and thickness swell.

Analysis of covariance was used because of the strong correlation between the measured variables and specific gravity. The analysis of covariance procedure (10) compares the adjusted treatment means shown in table A3 (appendix). The adjustment is to a common level of the covariate specific gravity, and was made to eliminate the effect that specific gravity has on the other variables, thereby giving a better indication of how the treatments affect these variables.

Paired comparisons were made across the two residue size classes and across the three flake types employing the simultaneous test comparison technique (3) and a 95 percent level of confidence. The significance statistics for these comparisons are included in appendix table A3. A significant interaction between residue size and flake type was found.

Table 2 contains underlined paired comparisons of flake-type panel properties for each residue source where averages were not significantly different.

Table 2 --Test means, and significance among means, for strength, stiffness, and dimensional stability of panels from three flake processes[1]

	Size of residue[2]	Panel types[3]		
		Disk-flake	Chipper fingerling-ring flake	Hand fingerling-ring flake
		INITIAL		
MOR (lb/in.²)	Large	2,746 (14.0)	2,380 (14.5)	2,707 (15.4)
	Small	3,336 (9.0)	2,946 (16.1)	3,032 (10.6)
MOE (10³ lb/in.²)	Large	504 (10.3)	427 (10.8)	488 (10.0)
	Small	487 (7.8)	419 (13.1)	441 (7.7)
IB (lb/in.²)	Large	53.0 (19.8)	49.8 (9.2)	41.5 (17.8)
	Small	46.3 (16.6)	54.8 (18.4)	49.4 (11.3)
		AFTER ACCELERATED AGING		
MOR (lb/in.²)	Large	2,066 (20.0)	1,725 (15.4)	2,143 (14.6)
	Small	2,657 (15.9)	2,133 (20.5)	2,341 (12.5)
MOE (10³ lb/in.²)	Large	387 (13.9)	295 (9.8)	377 (12.5)
	Small	453 (15.2)	325 (18.5)	364 (10.7)
IB (lb/in.²)	Large	22.7 (18.1)	26.9 (17.8)	20.8 (15.9)
	Small	25.3 (16.2)	27.9 (21.5)	22.2 (12.2)
		DIMENSIONAL STABILITY		
Linear expansion (pct)	Large	0.20 (10.0)	0.23 (22.3)	0.19 (29.2)
	Small	28 (55.7)	36 (9.5)	26 (7.7)
Thickness swell (pct) OD -VPS	Large	25.0 (8.0)	24.7 (3.5)	25.5 (3.7)
	Small	34.7 (9.7)	28.4 (3.9)	30.6 (2.4)

[1]Nonsignificant difference between paired comparisons (with 95 pct confidence) is indicated by underlined means.

[2]Large, 30-in. diameters without bark; small, 6- to 10-in. diameters with bark.

[3]Numbers in parentheses are standard deviation expressed as a percentage.

DISCUSSION

Panels produced from ring flakes derived from chipper-ejected fingerlings (oversize) were consistently lower in strength, stiffness, and internal bond than those from normal-size chipper fingerlings (table A2). This was true both before and after accelerated aging.

Other comparisons between panel flake types follow as derived from tables 2 and A3.

Initial Static Bending

With both the large and small residues, methods of flake production were shown by multivariate statistical analysis to make a significant difference in panel strength properties. Generally, panel property magnitudes decreased from hammermilled disk flakes to hand-split fingerling-ring flakes to modified drum chipper fingerling-ring flakes. The reduction in mean values of MOR and MOE (specific gravity corrected) for chipper ring-flake panels was 14 percent as compared to 15.5 percent for disk-flake panels. The internal bond levels for these boards were not significantly different.

Static Bending After Accelerated Aging

Each board type showed a significant difference in static bending values after accelerated aging. The adjusted mean value of MOR after accelerated aging was reduced 20 to 28 percent, and that of MOE 7 to 31 percent. The MOR and MOE levels were consistently less for chipper ring-flake panels as compared to disk-flake panels, and were statistically significant for all but the large raw material source for MOR. Internal bond for chipper ring-flake panels was the only level above 50 percent of initial levels.

Linear Expansion and Thickness Swell

Linear expansion was not significantly affected by the method of producing the flakes. Uncorrected or unadjusted linear expansion after OD-VPS ranged from 0.19 to 0.36 percent.

Thickness swell from ovendry to vacuum-pressure-soak (OD-VPS) showed little sensitivity to method of producing the flake. The magnitude differences were small (2 to 7 pct). Disk-flake flakeboards derived from small barky logs, however, showed a definite increase in thickness swell over flakeboards from the debarked large logs.

SUMMARY AND CONCLUSIONS

Disk flakes provide consistently better bending strength and stiffness than fingerling-ring flakes in homogeneous 3 percent phenolic flakeboard. Reductions in initial MOR of 14 percent and MOE of 15.5 percent resulted when modified drum chipper fingerling-ring flakes were employed instead of hammermilled disk flakes. After the ovendry to vacuum-pressure-soak treatment, the MOR and MOE values for all flake-type panels were considerably more than 50 percent of unaged values. Internal bond values after accelerated aging were consistently more than 50 percent of the initial values for chipper ring-flake panels only.

Production of a random three-layer panel equivalent in bending strength and stiffness to that employing disk-flake surfaces appears difficult (at equal panel weights). This might be accomplished, however, with further segregation of ring flakes from fingerlings into higher and lower quality fractions, and placement of the higher quality fraction in the surface layers of panels.

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APPENDIX

Table A1.--Average properties of control panels from three flaking processes before accelerated aging[1]

Number of panels	Log size	Bark	Thickness	Specific gravity[2]	Internal bond	Static bending: Modulus of rupture	Static bending: Modulus of elasticity
	In.		In.		Lb/in.[2]	Lb/in.[2]	1,000 lb/in.[2]
HAND-SPLIT FINGERLINGS							
3	30	No	0.518	0.59	41.5	2,710	487
3	6-10	Yes	.517	.59	49.4	3,030	441
DRUM CHIPPER FINGERLINGS							
[3]1	30	No	.515	.59	47.1	2,010	384
[3]1	6-10	Yes	.521	.60	49.5	2,610	389
[4]3	30	No	.512	.60	50.7	2,500	442
[4]2	6-10	Yes	.519	.59	57.4	3,110	434
DISK FLAKER							
3	30	No	.520	.60	44.9	2,750	504
2	6-10	Yes	.528	.59	58.5	3,340	487

[1]Number of specimens per panel: Static bending, 6; internal bond, 12.
[2]Specific gravity based on ovendry weight and dimensions at 65 pct relative humidity.
[3]Ejected material deposited beneath drum chipper.
[4]Material emerging normally from chipper chute.

Table A2.--Average properties of panels from three flaking processes after accelerated aging[1]

Number of panels	Specific gravity[2]	Internal bond	Static bending: Before aging[3]: Modulus of rupture	Static bending: Before aging[3]: Modulus of elasticity	Static bending: After aging[3]: Modulus of rupture	Static bending: After aging[3]: Modulus elasticity	Thickness increase over initial	Linear expansion[3] (OD-VPS)	Thickness swell[3] (OD-VPS)
		Lb/in.^{2}	Lb/in.^{2}	1,000 lb/in.^{2}	Lb/in.^{2}	1,000 lb/in.^{2}	Pct	Pct	Pct
				HAND SPLIT FINGERLINGS					
3	0.49	20.8	2,140	377	1,550	232	17	0.19	25.5
3	.46	22.2	2,340	364	1,470	182	27	.26	30.6
				DRUM CHIPPER FINGERLINGS					
[4]1	.49	21.3	1,390	266	1,020	166	17	.30	24.4
[4]1	.45	24.2	1,830	286	1,010	135	28	.32	28.1
[5]3	.49	28.7	1,840	305	1,300	182	19	.20	24.8
[5]2	.46	29.7	2,290	344	1,400	165	29	.38	28.7
				DISK FLAKER					
3	.50	22.6	2,070	387	1,470	233	18	20	25.0
2	.45	25.4	2,660	453	1,510	191	32	.28	34.7

[1]Number of specimens per panel: Static bending, 6; internal bond, 12.
[2]Specific gravity based on ovendry weight and dimensions at 65 pct RH.
[3]Calculated on thickness before and after accelerated aging.
[4]Ejected material deposited beneath drum chipper.
[5]Material emerging normally from chipper chute.

Table A3.--Test statistics[1] for comparison of adjusted treatment means from Table 2

Treatment level comparisons						Variables (unaged)			Variables (after aging)				
Flake H[2] residue		Flake C[2] residue		Flake D[2] residue		Modulus of rupture	Modulus of elasticity	Internal bond	Modulus of rupture	Modulus of elasticity	Internal bond	Linear expan- sion	Thick- ness swell
Large	Small	Large	Small	Large	Small								
*	*	--	--	--	--	0.1123	0.1308	0.1006	0.2831	0.1413	0.0870	0.2068	0.6526
--	--	*	*	--	--	.2544	.0329	.0360	.4934	.4486	.1034	.3997	.4736
--	--	--	--	*	*	.2432	.0241	.0575	.5706	.5971	.1814	.1891	.8411
*	--	*	--	*	--	.1999	.4693	.1859	.2124	.4458	.1968	.0495	.0962
*	--	*	--	--	--	.1494	.2983	.1074	.2027	.3706	.1760	.0408	.0953
*	--	--	--	*	--	.0001	.0478	.1767	.0263	.0003	.0093	.0007	.0387
--	--	*	--	*	--	.1535	.4429	.0215	.0974	.3591	.1138	.0304	.0120
--	*	--	*	--	*	.1588	.3577	.0769	.2716	.5536	.1680	.1844	.7193
--	*	--	*	--	--	.0389	.1346	.0283	.0304	.0725	.1620	.1656	.3824
--	*	--	--	--	*	.0608	.1322	.0171	.1644	.4131	.0728	.0025	.4448
--	--	--	*	--	*	.1588	.3558	.0749	.2660	.5426	.0126	.1080	.7188

[1]These test statistics are computed simultaneously and, in order to have a 95 pct confidence level, are to be compared to a critical value of 0.155, i.e., reject the hypothesis of no difference in the treatment level if the computed test statistic is greater than 0.155.

[2]Flake H: Hand fingerlings-ring flakes
Flake C: Drum chipper fingerlings-ring flakes
Flake D: Disk flakes.

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Structural flakeboards using ring flakes from fingerling chips, by Bruce G. Heebink, Erwin L. Schaffer, Joseph Chern, and James H. Haskell, Madison, Wis., FPL, 1977.

13 p. (USDA For. Serv. Res. Pap. FPL 296.)

Structural flakeboards were made from wood fingerlings produced from forest residues. Properties of these flakeboards were evaluated.

KEYWORDS: Disk flakes, fingerling chips, flakeboard, particleboard, residues, ring flakes, structural materials.

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